

SECTION 7: RADIOLOGICAL PROTECTION PROGRAM

7.1 Approval Record

- Reviewed by: Document Control Coordinator (Hiliary Burns)
- Approved by: Manager, ESH&A (Sean Whalen)
- Approved by: Deputy Director (Tom Lograsso)

The official approval record for this document is maintained in the Training and Documents Office, 105 TASF.

7.2 Revision/Review Information

The revision description for this document is available from and maintained by the author.

7.3 Purpose and Scope

This section deals with ionizing and non-ionizing radiation and is applicable to all Ames Laboratory activities. The information in this section is used to manage and control exposures to employees, visitors and the general public. Ames Laboratory safety programs are committed to keeping all exposures to ionizing and non-ionizing radiations As Low As Reasonably Achievable (ALARA).

7.4 Ionizing Radiation

7.4.1 Background Information

The Ames Laboratory [Radiation Protection Program \(RPP\)](#) establishes the framework for implementing the radiation protection requirements of 10 CFR 835, "Occupational Radiation Protection". The RPP is written to meet the specifications of 10 CFR 835.101 using the guidance in DOE G 441.1-1C, "Radiation Protection Program Guide".

The RPP is the compliance basis for Ames Laboratory's implementation of 10 CFR 835, *Occupational Radiation Protection*. The RPP applies to Ames Laboratory activities that involve the use of radioactive material and radiation emitting devices, and the mitigation of legacy radiological contamination. The RPP as written is not expected to hinder non-radiological activities at the Laboratory. The RPP refers to the implementation of the [Radiological Safety Program Description](#) (RSPD).

As Low As Reasonably Achievable (ALARA): [ALARA](#) is Ames Laboratory's approach to radiological protection, and is used to manage and control exposures (individual and collective) to employees, visitors, and the general public. ALARA is not a dose limit, but is a philosophy for devising processes, procedures and operations to maintain doses within applicable limits and as far below them as can be reasonably achieved. An ALARA committee has been established by the [ALARA Committee Charter](#), to make recommendations regarding the safety aspects of the possession, use, and disposition of sources of ionizing radiation by Ames Laboratory to ensure radiation exposures and releases are *ALARA*.

Ames Laboratory's policies and procedures are consistent with the ALARA philosophy. It is the policy of Ames Laboratory to conduct its activities in such a manner that worker and public safety, as well as protection of the environment, is given high priority. Ames

Laboratory management is committed to maintaining ionizing radiation risks to levels that are ALARA and to minimizing associated environmental, safety and health impacts in all activities. Both individual and collective exposures to laboratory workers, visitors, or members of the public, are maintained within appropriate regulatory limits and as far below such limits as social, technical, economic, practical, and public policy considerations permit.

7.4.2 *Program Information*

The core activities of the Ames Laboratory Radiation Protection Program are detailed separately in the following documents:

- [Ames Laboratory Radiological Protection Program Plan](#) (RPP)
- [Radiological Safety Program Description](#) (RSPD)

The RPP and RSPD cover radioactive material usage, radiation generating devices and sealed radioactive sources requirements. Users of these materials and devices are designated as Radiation Workers.

Dosimetry program: All Radiation Workers at Ames Laboratory are required to participate in the Laboratory's radiation dosimetry program. Prior to doing any type of radiological work, Ames Laboratory employees need to complete the following forms and return them to the Health Physics group at the Environment, Safety, Health, and Assurance office, G40 TASf:

- [Ames Laboratory Dosimetry Authorization Form.](#)
- [Ames Laboratory Employee Radiation Dosimetry Badge Agreements and Commitments.](#)

7.4.3 *Roles and Responsibilities*

The following are the roles and responsibilities as they relate to radiation safety at Ames Laboratory. For a complete list of roles and responsibilities please see the [Line Management Roles and Responsibilities](#) at Ames Laboratory policy.

Division, Institute and Program Directors and Department Managers

- Ensure a safe work environment, including approval of activities falling under Readiness Review, by conducting walkthrough inspections of laboratory spaces assigned to their group leaders, participating in independent walk-throughs, implementing and conducting worker observations, ensuring training completion by all divisional/departmental staff, allocating resources to address safety concerns and maintain safe work environments, and serving as the group's safety coordinator (unless otherwise designated).
- Ensure group leaders and supervisors under their direction complete the Planned Activities Form for new employees to assign the correct safety training courses; oversee training completion by employees under their direction, including General Employee Training and other mandatory institutional training as well as job-specific training.

Safety Coordinator

- Ensure new employees are given [Emergency Awareness Training](#).
- Attend Hazard Identification and Safety Coordinator/Representative Development training and other training as directed by the program director and in consultation with ESH&A.

Group Leader

- Comply with hiring and checkout procedures, conduct performance appraisals, complete the Planned Activities Form for new employees, monitor and ensure employees have met all training requisites, and approve leave requests and timesheets.
- Serve as the personnel supervisor for group staff unless otherwise designated; conduct performance appraisals for direct reports (including secondary review as appropriate); accurately identify hazards and training needs for their employees through the use of the Planned Activity form.
- Ensure supervisors and employees under their direction complete the Planned Activities Forms for their groups, either as templates or for each individual employee; oversee training completion by supervisors and staff under their direction, including GET and other mandatory institutional training and job-specific training.
- Provide job-specific training to ensure supervised employees can perform all work activities in a safe and healthy manner; prepare and maintain job-specific training records
- Ensure that visitors to their areas are properly supervised or trained and follow Laboratory policies and procedures; serve as a host to visitors and foreign nationals.

Group Safety Representative

- Assist the safety coordinator (when necessary) with providing [Emergency Awareness Training](#) to new employees.
- Attends Hazard Identification and Safety Coordinator/Representative Development training and other training as directed by the group leader and in consultation with ESH&A.

Group Administrators

- Participate in mandatory ACSM cyber security training.

7.4.4 Training

7.4.4.1 Institutional Training Modules

Institutional training modules are assigned to Ames Laboratory personnel based on the readiness review activities they will be participating in while working at the Laboratory. It is the responsibility of the Group Leader/Supervisor to ensure all work has been appropriately identified for each employee. Listed below are institutional trainings that are relevant to the Ames Laboratory ESH&A, Radiological Protection:

RADIOLOGICAL WORKER II (RADIATION GENERATING DEVICES)	
Intended Audience:	<i>Required for all workers whose job assignment involves entry into Radiological Buffer Areas, Radiation Areas, and Radioactive Materials Areas.</i>
Module Format:	<i>Self-study. Consists of a study guide, challenge exam and practical factors evaluation (PFE). Estimated completion time 2.0 hours/exam and 1 hour/PFE.</i>
Associate Retrain Period & Format:	<i>Two-year retrain. Study guide, challenge exam PFE.</i>

RADIOLOGICAL WORKER II (RADIOACTIVE MATERIALS)	
Intended Audience:	<i>Required for all workers whose job assignment involves entry into Radiological Buffer Areas, Radiation Areas, and Radioactive Materials Areas.</i>
Module Format:	<i>Self-study. Consists of a study guide, challenge exam and practical factors evaluation (PFE). Estimated completion time 2.0 hours/exam and 1 hour/PFE.</i>
Associate Retrain Period & Format:	<i>Two-year retrain. Study guide, challenge exam PFE.</i>

RADIOLOGICAL WORKER II (SEALED RADIATION SOURCE)	
Intended Audience:	<i>Required for all workers whose job assignment involves the use of sealed radioactive source(s).</i>
Module Format:	<i>Online instruction with quiz. Estimated completion time: 1.5 hours.</i>
Associate Retrain Period & Format:	<i>Two year retrain, online instruction with quiz.</i>

7.4.4.2 Group/Activity Specific Training

Group/activity specific training shall be given to each employee by the Group Leader, Department Manager or Activity Supervisor. Radiological Workers, shall read and understand experiment SOPs, work processes, personal protection equipment requirements.

7.4.5 References

The core activities of the Ames Laboratory Radiation Protection Program are detailed separately in the following documents:

- [10 CFR 835, Occupational Radiation Protection](#)
- [DOE G 441.1, Radiation Protections Guide for Use with Title 10, CFR, Part 835, Occupational Radiation Protection](#)
- [Ames Laboratory Radiological Protection Program Plan](#) (RPP)
- [Radiological Safety Program Description](#) (RSPD)

7.5 Non-ionizing Radiation

This section deals with the following safety areas: Lasers, Radio Frequency Radiation (RFR), and Magnetic Fields.

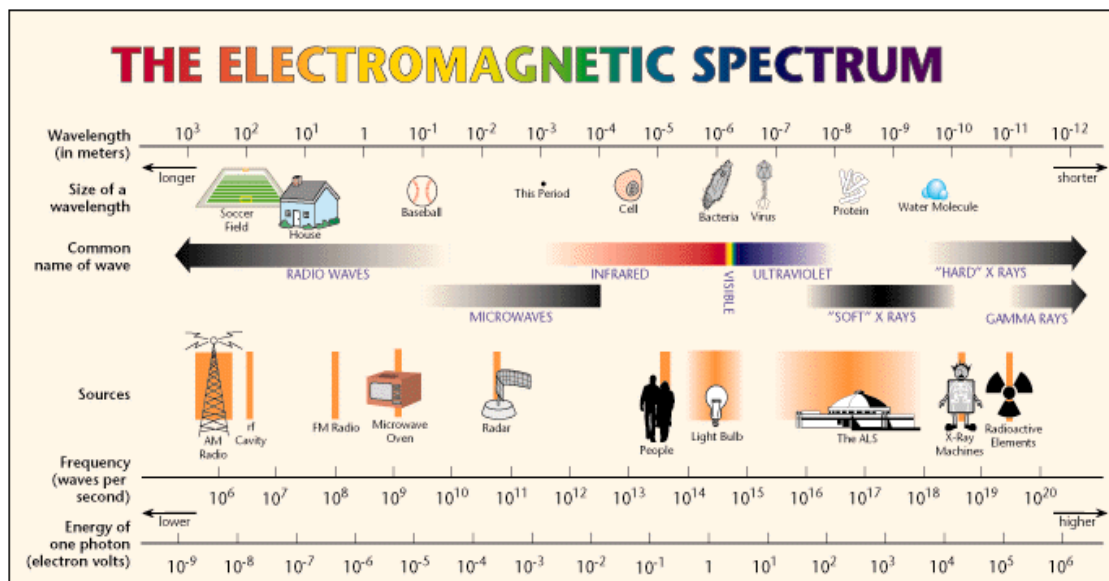
Non-ionizing radiation (NIR) is a generic term used to describe electromagnetic radiation that does not carry enough photon energy to ionize atoms or molecules and, as per its definition, also includes mechanical waves (infra- and ultrasound). Electromagnetic radiation at frequencies below the UV band is classified as non-ionizing radiation. See Figure 1.0.

Electromagnetic Spectrum:

Ionizing Radiation: Electromagnetic radiation at frequencies above the UV band are classified as "ionizing radiation", because they have enough energy to effect changes in atoms by liberating electrons (ionizing) and thus altering their chemical bonds. X-rays and gamma rays are common forms of ionizing radiation.

Ionizing radiation occurs at frequencies above 2900 THz (2900×10^{12} Hz). This corresponds to a wavelength of about 103.4 nm, which lies near the lower wavelength-edge of the Ultraviolet (UV) spectrum.

Figure 1.0, The Electromagnetic Spectrum



7.5.1 Lasers

A laser is a device that emits photon radiation through a process of optical amplification based on the stimulated emission of photons. The term "laser" serves as an acronym for *Light Amplification by Stimulated Emission of Radiation*. The emitted laser light covers the IR, visible and UV electromagnetic spectrum and is noted for its high degree of spatial and temporal coherence.

7.5.1.2 Background Information

The Ames Laboratory Laser Safety Program is designed to ensure the safe use of laser in research activities, as well as the safety of personnel and visitors to the Laboratory who may face potential exposure to lasers. Effective management of laser operations requires adherence to the principles of Integrated Safety Management: 1) define the scope of work, 2) analyze the hazards, 3) identification and implementation of hazard controls, 4) performing work within controls and 5) continuous improvement through regular feedback.

7.5.1.3 Program Information

All Class IIIB and IV lasers and laser systems are required to be operated in accordance with the requirements established by the American National Standards Institute (ANSI) Z136 series, Standards for the Safe Use of Lasers and the [Laser Safety Manual](#). Laser operators are required to follow the guidance of this manual.

AMERICAN NATIONAL STANDARD (ANSI) FOR SAFE USE OF LASERS

Z136.1: The Ames Laboratory Laser Safety Program meets or exceeds the requirements of ANSI Z136.1. A copy of this standard is available in the ESH&A office (G40 TASF, 294-2153).

IOWA STATE UNIVERSITY LASER SAFETY MANUAL: Ames Laboratory implements the requirements listed in ISU's [Laser Safety Manual](#). One major difference exists in that Ames Laboratory requires Class IV laser systems to have interlocks. Some minor nomenclature differences also exist between the two organizations. For example, ISU uses the term "Principal Investigator" while Ames Laboratory uses the term "Group Leader".

LASER HAZARD ASSESSMENT (LHA): ESH&A personnel shall conduct a review of current LHA information of each Class IIIB and IV laser system on an annual basis. This review will consist of a verification of: 1) the IIIB and IV laser inventory, 2) authorized users and 3) the current LHA information on file. Formal LHAs will be conducted whenever there is a significant change in the laser system or at the time of the Readiness Review for the research activity. Sample [LHA forms](#) shall be maintained in the ESH&A office.

READINESS REVIEWS: Research activities involving laser operations shall be reviewed in accordance with the Laboratory's Readiness Review procedure.

7.5.1.4 Roles and Responsibilities:

The following are the roles and responsibilities as they relate to laser safety at Ames Laboratory. For a complete list of roles and responsibilities please see the [Line Management Roles and Responsibilities](#) at Ames Laboratory policy.

Laboratory Director: The Laboratory Directory is ultimately responsible for ensuring that worker protection from laser hazards is accomplished via the enforcement of laser safety policies and procedures described in this manual.

Division/Institute/Program Directors: Division/Institute/Program Directors shall ensure that relevant laser safety policies and procedures are implemented at the programmatic level.

Group Leader: Group Leaders shall ensure that relevant laser safety policies and procedures are implemented at the research group level. Group Leaders shall assure all activities involving lasers have been reviewed via the Readiness Review procedure. Group Leaders shall also ensure all laser users are authorized, trained and medically-approved to use lasers and that an approved Standard Operating Procedure (SOP) is being followed that includes the use of appropriate Personal Protective Equipment (PPE). Work practices are regularly observed and any deficiencies corrected.

Environment, Safety, Health & Assurance (ESH&A): The ESH&A office shall assist Program Directors, Group Leaders and other Laboratory personnel in the implementation of laser safety policies and procedures. ESH&A personnel conduct annual laser hazard assessments and conduct activity reviews that include laser operations. ESH&A shall maintain an inventory of all Class 3B & 4 lasers, providing technical assistance, verifying training records and facilitating the completion of training.

Laser Worker: Laboratory employees who work with lasers shall 1) be aware of the hazards, 2) comply with all mandatory training and medical surveillance requirements, 3) work in accordance with established policies and procedures keeping with safe work practices when working with laser including the use of proper PPE, and 4) report unsafe work conditions to their supervisor and/or ESH&A.

Laser Safety Officer (LSO): A member of the ESH&A, Health Physics group that serves as a point of contact for resolving laser safety issues. The Ames Laboratory LSO shall be in communication with the ISU LSO on programmatic issues, as appropriate.

Occupational Medicine: Responsible for providing laser safety eye exams to all users of Class 3b & 4 lasers.

Engineering Services: Responsible for installing and performing maintenance checks on interlock systems (lasers and X-ray systems).

7.5.1.5 Training

Institutional training modules are assigned to Ames Laboratory personnel based on the readiness review activities they will be participating in while working at the Laboratory. It is the responsibility of the Group Leader/Supervisor to ensure all work has been appropriately identified for each employee. Below is the institutional training that is relevant to the Ames Laboratory Laser Safety Program:

INITIAL LASER SAFETY, ALAB-LASERINITIAL	
Intended Audience:	<i>Mandatory for all class 3B and class 4 laser users. .</i>
Module Format:	<i>Online instruction with quiz. Estimated completion time: 3 hours.</i>
Associated Retrain Period & Format:	<i>Two year retrain, online instruction with quiz.</i>

RETRAIN LASER SAFETY, ALAB-LASERRETRAIN	
Intended Audience:	Mandatory for all class 3B and class 4 laser users. .
Module Format:	Online instruction with quiz. Estimated completion time: 1.5 hours.
Associated Retrain Period & Format:	Two year retrain, online instruction with quiz.

7.5.1.6 Group/Activity Specific Training

Group/activity specific training shall be given to each employee by the Group Leader, Department Manager or Activity Supervisor prior to work that includes a discussion of beam line hazards, non-beam hazards, hazard mitigation, location of laser system PPE and other safety information, emergency response measures and any other procedural information. Each laser worker shall read and understand the laser system SOPs, work processes and be familiar with PPE requirements.

7.5.1.7 Medical Surveillance

Medical surveillance is required for laser workers who will be or have worked with Class 3B and Class 4 lasers at Ames Laboratory or another institution and have had or suspect a laser eye injury. Before conducting laser activities at Ames Laboratory, users must schedule an appointment for a baseline eye exam with Occupational Medicine, (515) 294-2056, located at G11 Technical and Administrative Services Facility (TASF).

7.5.1.8 References

- [10 CFR 851, Worker Safety and Health Program](#)
- AMERICAN NATIONAL STANDARD (ANSI) FOR SAFE USE OF LASERS Z136.1 (A copy is available at ESH&A, G40 TASF).
- [IOWA STATE UNIVERSITY LASER SAFETY MANUAL](#)
- [LASER HAZARD ASSESSMENT \(LHA\) form](#)

7.5.2 Radio Frequency Electromagnetic Fields (RFR)

7.5.2.1 Background Information

Use of devices that generate radio frequency radiation (RFR) is an important part of several of the Laboratory's research programs. The hazards associated with RFR are potentially significant and demand an effective management program. This section describes the protection mechanisms designed to ensure worker protection from RFR.

7.5.2.2 Program Information

Ames Laboratory follows the guidance in American Conference of Governmental Industrial Hygienists (ACGIH) Handbook entitled "Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices"

and ANSI/IEEE Standard C95.1, “Safe Levels With Respect to Human Exposure to RF Radiation, 3kHz to 300 GHz.” In addition, guidance from the Federal Communication Commission (FCC) is applied where RF transmitting systems are used. These sources, along with the information contained in this section constitute the Laboratory’s written program. The basic elements of the Laboratory’s program are:

- ESH&A surveys/calculations of RF systems,
- Readiness Review procedures, and
- Group-specific safety training for users.

Radiofrequency transmitting antennas are regulated by the Federal Communication Commission or FCC. The FCC has established safety envelopes applicable to RF transmitter sites. These envelopes provide maximum permissible exposure (MPE). The MPE are in two categories: *Controlled Environment RF* area and *General Population/Uncontrolled RF* area.

Controlled Environment RF area is an area where the activity of personnel within a space is subject to controls established by an RF safety program for purposes of maximum permissible exposure (MPE) limits given in IEEE Std C95.1-2005. A Controlled Environment RF area must be established when the recommended limits are exceeded. Workers entering these Controlled Environment RF area must be fully aware of the potential for exposure and can exercise control over their exposure.

A General Population/Uncontrolled RF area is an area accessible by the general public. The MPE cannot be exceeded in the General Population/Uncontrolled RF area.

Radio Frequency is Non-ionizing Radiation: Radiation is characterized by its effect upon absorption as either ionizing or non-ionizing radiation. Ionizing means that there is sufficient energy to change the chemical structure of the absorbing matter by removing one or more electrons, creating an electrically charged particle (ion). Non-ionizing means there is not enough energy in the radiation to create ions. Instead, the energy is absorbed and creates heat. Because of its low energy, RFR is non-ionizing radiation.

RFR does not directly alter molecular structure. When RFR is absorbed, it results in an increase in molecular movement. This is sensed as heat. RFR, which is low frequency and low-energy, produces relatively low amounts of heat in biological tissue. Non-ionizing radiation is not known to damage DNA in the manner that ionizing radiation does.

Hazard Communication: For transmitting systems Controlled Environment RF areas must be posted. Area around systems that exceed the MPE limits must be marked. For non-transmitting systems that utilize RFR for sample manipulation mitigation of RFR hazards must be addressed during the Readiness Review process.

7.5.2.3 Training

Currently, there is no institutional training module for the Radio Frequency (RF) Radiation-Generating Devices Program. However, all affected populations are required to read this program and comply with the requirements discussed in the section.

Group/activity-specific training shall be given to each employee prior to work that includes a discussion of RFR hazards and other safety information. In addition the group/activity training shall review emergency response measures and any other procedural information. This training shall be documented by the Group Leader/Department Manager.

7.5.2.4 References

- American Conference of Governmental Industrial Hygienists (ACGIH) Handbook "Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices"
- ANSI/IEEE Standard C95.1-2005, Safe Levels With Respect to Human Exposure to RF Radiation, 3kHz to 300 GHz
- International Commission on Non-Ionizing Radiation Protection Guidelines for Limiting Exposure to Time-varying Electric, Magnetic and Electromagnetic Fields (up to 300 GHz). Published in: Health Physics 74 (4):494-522;1998

7.5.3 Magnetic Fields

7.5.3.1 Background Information

Use of magnet systems is an important part of research conducted at Ames Laboratory. The hazards associated with high-powered magnets are significant and demand an effective management program. This section describes the requirements and these rules are designed to minimize employee exposures and therefore ensure worker protection from electric and magnetic fields.

7.5.3.2 Program Information

Ames Laboratory uses guidance specified in the American Conference of Governmental Industrial Hygienists (ACGIH) TLV booklet entitled "Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices" to develop magnetic field safety envelopes, specifically the section entitled "Non-Ionizing Radiation and Fields," which addresses acceptable magnetic and electric field exposure levels for these systems.

Exposure Limits: A magnetic field is a force field created by a magnet or as a result of the movement of charges. The magnitude or intensity of a magnetic field is measured in tesla (T or mT). It may also be given in Gauss (G). Note one gauss (G) equals 0.0001 tesla (T). Magnet systems at Ames Laboratory are required to identify the 5 gauss (0.0005 T) line around each respective system. This can be accomplished using stanchions and rope/chains or tape lines on the floor. See figures 2 and 3 below for examples.

Door signage is considered to be the minimum form of employee notification coupled with indication of the 5 gauss line around the system. Contact the ESH&A, Health Physics section, for the correct signage for door posting.



Figure 2. Tape making on the floor at or near the 5 gauss line.



Figure 3. Tape makings on the floor and stanchions at or near the 5 gauss line.

7.5.3.3 Training

Currently, there is no institutional training module for the operation of magnets or magnet systems. Group or activity-specific training shall be given to each employee prior to work that includes a discussion of magnetic fields and other pertinent safety information. Verification of group or activity-specific training is conducted during Readiness Review.

7.5.3.4 References

- American Conference of Governmental Industrial Hygienists (ACGIH) Handbook "Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices"
- ANSI/IEEE Standard C95.1 Safe Levels With Respect to Human Exposure to RF Radiation, 3kHz to 300 GHz
- International Commission on Non-Ionizing Radiation Protection Guidelines On Limits of Exposure to Static Magnetic Fields, published in Health Physics 96(4):504-514; 2009